

The Occupational Safety and Health Administration has advanced engineering controls over administrative controls and protective equipment to reduce exposures to chemicals in the workplace. The application of employee training and motivation programs (such as job safety analysis) to reduce exposures to chemicals has not been emphasized. To determine the effectiveness of such programs, a pilot project in an alkyl lead production facility was conducted with 35 employees in an effort to reduce exposures to organic and inorganic lead. Results after 12 months show a 40% reduction in lead-in-urine and a 24% reduction in lead-in-blood, both indicators of total exposure to organic and inorganic lead.

## Effectiveness of employee training and motivation programs in reducing exposure to inorganic lead and lead alkyls

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### introduction

To determine the success of training programs in reducing exposures to chemicals, a method of monitoring exposure by all routes including inhalation, skin absorption and ingestion is required. Lead-in-urine and lead-in-blood are well documented as integrating the total exposure to organic lead and inorganic lead.<sup>(1)</sup> Several studies have found no correlation between air monitoring and biological values,<sup>(2,3)</sup> probably because of exposures by routes other than inhalation.

An employee training and motivation program was developed and implemented at the Ethyl Corporation's Baton Rouge alkyl lead manufacturing plant in January, 1980. For over 40 years Ethyl has used biological sampling to monitor the health of employees exposed to lead. Medical surveillance standards were established to take remedial action prior to the appearance of clinical symptoms. Combined with air monitoring data, the biological information has resulted in the implementation of engineering controls, respiratory protection programs and administrative controls.

Employees included in the pilot program consisted of 35 foremen responsible for alkyl lead production. The objective was to reduce the lead-in-urine and lead-in-blood levels through 1) comprehensive training on the industrial hygiene aspects of lead and 2) motivating employees to minimize exposure by using good work practices. At the beginning of the program, the urine and blood lead levels of the 35 foremen were elevated over nonoccupationally exposed levels (Table I).

### methodology

The foremen were divided into four groups consisting of 8 to 9 foremen on each of the four shifts. Group meetings were held on a monthly schedule. The initial meeting consisted of an intensive training session on the industrial hygiene aspects of working with organic and inorganic lead. The purpose was to assure that employees were informed of the

physical and toxicological aspects of tetraalkyl lead (organic) and inorganic lead. Since organic and inorganic lead coexist in the alkyl lead production facility, it was very important for the employees to understand the effect that exposure to each form of lead would have on urine and blood lead levels.

In all training sessions, the importance of good work practices and personal hygiene was stressed. Examples include 1) washing of the hands and face before eating, drinking and smoking 2) keeping fingernails short and clean 3) changing to clean work clothing on a daily basis, and 4) informing the foremen that wiping the face with a shirt sleeve to remove perspiration could result in ingestion of lead particulate. Ingestion of inorganic lead was considered to be a major contributor to elevated blood lead levels.

Each employee received quantitative respirator fit testing and training. The importance of the proper use and care of the respirator was emphasized, especially the need to clean the dust from the respirator after use. Air-supplied respirators and half-facepiece dual cartridge respirators are used to protect employees from inorganic lead dust and fume and organic lead vapor. The air-purifying respirators are NIOSH approved for organic vapor, dust, mist and fumes.

Biological samples were collected on a monthly basis for urine and bimonthly for blood. The lead-in-blood and urine values were discussed with the groups during the group meetings. The average blood and urine values for the groups were computed and compared.

### biological sampling (analytical methods)

All biological samples were analyzed by Ethyl's Toxicology and Industrial Hygiene Laboratory which is licensed by the Center for Disease Control. Urine samples were decomposed with nitric acid and ashed in a muffle furnace. The residue was dissolved in acid and the lead content measured as lead dithizonate by use of a spectrophotometer.<sup>(4)</sup>

**TABLE I**  
Results of Monitoring Lead-in-Urine and Blood  
January and December of 1980

Employee	Lead-in-Blood $\mu\text{g/dL}$			Lead-in-Urine $\mu\text{g/L}$		
	Begin (1)	Final (12)	Change ( $\Delta$ )	Begin (1)	Final (12)	Change ( $\Delta$ )
1	25	14	-11	48	31	-17
2	42	24	-18	91	52	-39
3	48	29	-19	202	52	-150
4	39	49	+10	95	107	+12
5	45	30	-15	154	58	-96
6	49	34	-15	162	107	-55
7	38	28	-10	86	87	+1
8	53	25	-28	137	65	-72
9	33	25	-8	25	64	+39
10	28	29	+1	46	42	-4
11	37	34	-3	117	47	-70
12	28	24	-4	164	45	-119
13	52	40	-12	124	68	-56
14	48	33	-15	94	68	-26
15	41	28	-13	87	53	-34
16	49	37	-12	75	27	-48
17	29	21	-8	87	61	-26
18	18	20	+2	34	26	-8
19	43	29	-14	162	55	-107
20	70	50	-20	116	81	-35
21	22	19	-3	79	76	-3
22	45	29	-16	116	88	-28
23	44	44	0	102	54	-48
24	62	48	-14	131	45	-86
25	47	30	-17	71	32	-39
26	48	42	-6	68	46	-22
27	35	32	-3	90	54	-36
28	27	22	-5	68	36	-32
29	44	28	-16	94	62	-32
30	43	52	+9	138	69	-69
31	50	41	-9	134	142	+8
32	59	42	-17	120	74	-46
33	56	35	-21	149	89	-60
34	48	30	-18	99	64	-35
35	42	26	-16	133	86	-47
Average	42	32	-10	106	63	-42
Percent Change in Average Values:						
			24%			40%

Blood samples were collected during months 1, 2, 4, 6, 8, 10 and 12. These samples were analyzed by the anodic stripping technique. This technique involves lysing the erythrocytes and measuring the lead content of the sample electrochemically.<sup>(5)</sup>

## results

Results of the employee motivation and training program on lead-in-blood and lead-in-urine are presented in Table I.

### lead in urine

The average reduction in urinary lead for all foremen during the 12-month program was 42  $\mu\text{g/L}$  or 40% of the initial lead-in-urine level. The average reduction of the 17 employees with initial lead-in-urine levels over 100  $\mu\text{g/L}$  was 72  $\mu\text{g/L}$  or 52%.

A plot of average lead-in-urine on a monthly basis is presented in Figure 1.

### lead in blood

As lead-in-blood has a longer half life than the elimination rate of lead-in-urine, a smaller reduction of lead-in-blood than lead-in-urine was anticipated during the 12-month interval. Table I also shows the results of the initial and final lead-in-blood samples and the total change. The average reduction for the total population was 10  $\mu\text{g/dL}$  or 24% of the initial average lead-in-blood level. All employees with initial blood lead values of 50  $\mu\text{g/dL}$  or greater were combined into a subgroup. This value was chosen as it is the blood lead restriction level which OSHA's inorganic lead standard requires in 1983.<sup>(6)</sup> This subpopulation had an average blood lead reduction of 17  $\mu\text{g/dL}$ . Of seven employees with blood leads of 50  $\mu\text{g/dL}$  or greater at the beginning of the program, only one remained at 50  $\mu\text{g/dL}$  at the end of one year.

The plot of average lead-in-blood on a monthly basis is presented in Figure 2.

## statistics

All reductions of lead-in-urine and lead-in-blood as indicated in the results section are statistically significant ( $\alpha$  of 0.0005). The statistical analysis consisted of a t-test of matched pairs (dependent samples).

## discussion

The reduction of lead-in-urine and lead-in-blood levels indicate a significant reduction in exposure. Based on these data,

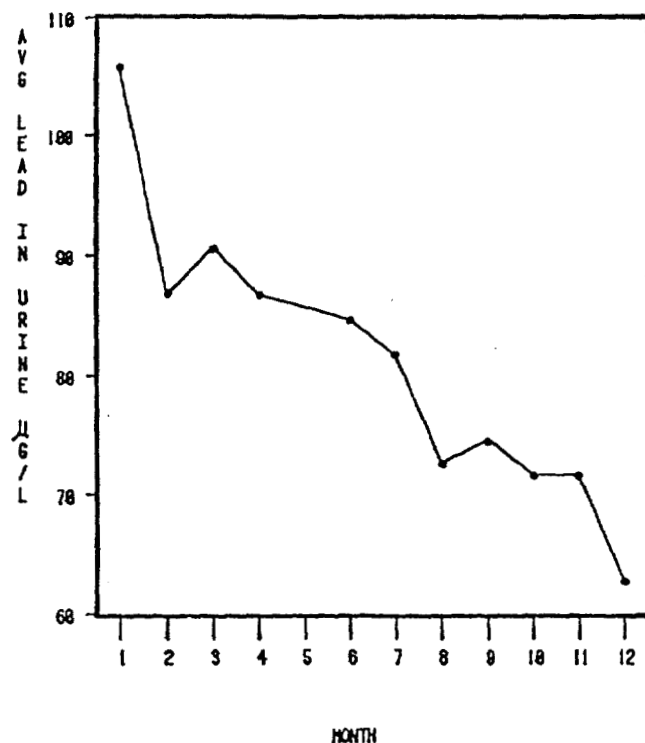


Figure 1 — Average lead-in-urine by month.

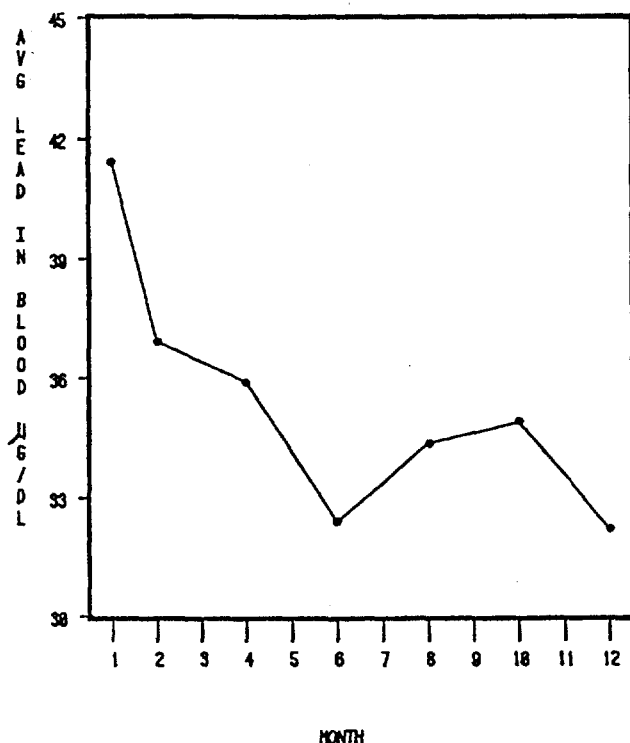


Figure 2 — Average lead-in-blood by month.

an employee motivation program appears to be an effective method of reducing employee exposure to chemicals. The program is especially effective with employees having the higher lead-in-blood and urine levels. Work practices, protective equipment and personal hygiene become increasingly important as the level of exposure increases. The capital investment in an employee training and motivation program is minimal compared to engineering controls. Benefits of the program were observed outside of the employees in the pilot project. When the foremen observed the reduction of lead-in-urine and lead-in-blood values, they shared the information with the people reporting to them. The foremen applied many of the training and motivation techniques used in the pilot study to their groups with significant success.

We believe that the employee motivation section of the program contributed to the reduction of lead-in-urine and

lead-in-blood. During the group meetings, the employees were observed to concentrate their discussions on the work areas of employees whose lead-in-blood or urine level had increased or was adversely affecting the average of the group.

In October, 1980, the program was expanded to include all employees with blood leads over 50 µg/dL or urinary lead values over 120 µg/L. A reduction of lead-in-urine and blood has been observed in the initial 10 months of the program. We have found that working with the employee on a one-to-one basis rather than in large groups allows the program to be tailored to the employee's specific job. If the employee's lead-in-blood and lead-in-urine levels remain elevated, a job safety analysis is conducted to correct the work practices resulting in elevated exposure.<sup>(7)</sup>

The concepts used in this program have been effectively applied in industrial safety for several years. Safety professionals have recognized the need for employee training to control the frequency and severity of accidents in the workplace. The successful application of training programs to industrial hygiene offers the industrial hygiene/management team a cost-effective and proven method of reducing exposures.

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